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CONTRASTING WEATHERING RATES IN COASTAL, URBAN AND RURAL AREAS IN SOUTHERN BRITAIN: PRELIMINARY INVESTIGATIONS USING GRAVESTONES

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ABSTRACT

Weathering rates were calculated using the height differences between lead lettering on marble gravestones from inland urban, inland rural, coastal urban and coastal rural sites within southern Britain. All sites exhibit similar amounts and variations in rainfall over the study period for which gravestone measurements are available. Comparison of mean weathering rates suggested that the coastal urban site of Clacton had a similar weathering rate to the nearby coastal rural site. The other urban sites of Oxford, Lodge Hill and Portsmouth had similar weathering rates, despite their diverse locations and histories. The inland rural site had a significantly lower mean weathering rate than any other site. Analysis of covariance confirms that there are similarities between some sites. Linear and curvilinear regression of depth of loss against age suggests that a linear regression adequately describes the relationship over the period for which data are available, although there are problems with this simple interpretation. Copyright © 2000 John Wiley & Sons, Ltd.

KEY WORDS: gravestones; weathering rates; polluted atmospheres

INTRODUCTION

The study of the degradation of building stones in polluted environments is a topic of continuing academic and commerical interest. Establishing the modes and rates of degradation is important in determining the accuracy of current standards, such as the crystallization test (Ross and Butlin, 1989), in reflecting and predicting the service life of stone. Academically, the study of different rock types in different combinations and in different environmental settings provides an, as yet, little tapped source of information on relationships between processes and forms over known time spans. Studies of contemporary rates of alteration have concentrated upon using simple aggregate indices of loss, such as weight change (e.g.Honeybourne and Price, 1977; Jaynes, 1985; Inkpen, 1989; Butlin *et al.*, 1992) or upon the relationship between rainfall and runoff from known areas (e.g. Reddy, 1988; Webb *et al.*, 1992).

Studies of contemporary degradation tend to use methods and interpret results without any reference to the historical context within which degradation occurs. These studies are concerned only with linking relatively short-term changes in the stone to equally short-term changes in variables such as sulphur dioxide and rainfall. The National Materials Exposure Programme (1987–1995), for example, was a major project designed to assess the variability of degradation across the UK (Butlin *et al.*, 1992, 1993). The survey was carried out by the Building Research Establishment, the government agency (now a private company) responsible for building standards and research within the UK. Building stone degradation was assessed using small ($50 \times 50 \times 8$ mm) tablets of different stone types (Monks Park, Portland Stone limestones and White Mansfield sandstone) exposed at 27 sites across the UK. Linear and multiple regression analyses were then used to derive a set of relationships between weathering loss and environmental variables between sites. A similar study by Jaynes (1985) used industrial, commercial, residential and rural sites, to permit a comparison of the impact of different pollution environments on weathering loss across southeast England. Likewise,

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Inkpen (1989) contrasted urban and rural sites across southern Britain identifying and quantifying changes in this gradient as environmental variables changed over southern Britain. Although these studies are useful for providing a pool of data derived by the same techniques across a range of sites, they could not provide a historical context of degradation within which to interpret the results.

Pollution environments and rates of weathering seem to alter over time and not necessarily synchronously (Cooke, 1989). Variations in weathering rates can occur over time scales much greater than the usual one to five year time scales of exposure studies. Trudgill *et al.* (1994), in comparing short-and long-term weathering loss from tablets eroded within a soil profile, highlighted the difference between losses measured yearly and those actually experienced over a decade, the latter being much lower than would be predicted by extrapolating yearly losses. Additionally, the importance of antecedent weathering behaviour for future weathering loss is an aspect not usually considered. On real buildings weathering history will be a fundamental determinant of current weathering behaviour. The complicated lag effects associated with storage of weathering products and agents such as salts, the so-called 'memory' effect, could be one possible reason for elevating weathering rates above those expected from contemporary environmental conditions alone (Smith *et al.*, 1988; Cooke, 1989; Murphy and Inkpen, 1996). Short-term studies, therefore provide only limited information about the nature of differences in weathering between different environments. Issues concerning the variability of weathering between different weathering environments over long periods of time and the potential determinants of such variability are not considered.

GRAVESTONES AS INDICATORS OF WEATHERING OVER TIME

Gravestones have been used in a number of studies to try to determine the historical context within which current weathering studies could be placed and so provide some answers to the issue of temporal and spatial variabilities in weathering (Geikie, 1880; Dragovich, 1986; Meierding, 1981; Rahn, 1969; Kupper, 1975; Cooke *et al.*, 1995). Cooke *et al.* (1995), for example, determined both the weathering loss or weathering rate and rate of change of weathering rate from measurement of surface loss from Carrara marble gravestones at three different urban locations. Comparison of the three sites –Swansea, Portsmouth and Wolverhampton – suggested that the site associated with heavy industry in the past, (Swansea), had statistically significantly higher weathering loss than the two less industrialized sites. Furthermore, Portsmouth and Wolverhampton, despite detailed differences in history and environments, such as coastal and inland locations, had similar weathering losses. By using analysis of covariance the authors compared the relationship between sites rather than just a single mean weathering rate. Care needs to be taken in undertaking such a comparison, however, as heteroscedasty in the data could influence the analysis. In the study by Cooke *et al.* (1995) none of the sites showed any significant systematic variation in plots of residuals against predicted y values.

Cooke *et al.* (1995) also compared the rate of change of weathering loss over time. Both Portsmouth and Wolverhampton had insignificant changes in weathering rates, but Swansea exhibited a statistically significant increase in weathering rate of $0{\cdot}3\ \mu$m per year. The accuracy of the engineering callipers (0·01mm), however, meant that it would take 30 years of weathering before the weathering loss was altered by a measurable amount.

Gravestones have been useful in deriving indications of historical weathering losses for a number of reasons. Gravestones, particularly those of Carrara marble, are widespread dated surfaces which have been exposed for different periods of time across a range of environments. Comparison between locations is possible using the same measurement technique, the lead lettering index. The difference between the level of the lead lettering and the surface of the marble is taken to represent the amount of surface loss since the gravestone was exposed (e.g.Dragovich, 1986; Neil, 1989, Cooke *et al.*, 1995). Lettering is cut into the surface of the marble then either molten lead is poured into the cut or pre-formed lead lettering is 'tagged' into the cut. Once inserted, the lead lettering and marble are polished so the lead lettering finishes flush to the marble surface. Over time, the marble is differentially weathered and the lead acts as a reference surface against which a set of callipers or engineering depth gauge can rest.

This technique is not without problems, however. Graveyards are found at various locations within an urban area and hence their pollution histories differ. Some Victorian graveyards are on the outskirts of towns

in predominantly rural locations, whilst others in previously rural sites have been incorporated into suburbs by urban growth. An assumption of similarity of pollution environment over time cannot be made for any single graveyard. Land use around each graveyard in this study was classified on the basis of current land use. Without detailed historical reconstruction of the pollution environment of each site, which may not be possible given the documentation available, the nature and extent of any changes in land use is unknown. The working assumption is that classification such as ‘urban’ have meant similar things for urban areas within the UK over time. A similar assumption is used for ‘rural’ sites in this study. Whilst this may be more valid than for urban sites, the background level of pollution that the rural sites are meant to represent has not remained static either, even at the relatively short scale of a decade (Inkpen, 1989).

The lead lettering is usually fixed, but can ‘peel’ off the marble surface. This usually happens as weathering loss reaches the peg holes into which the lettering is fixed. In some locations, however, weathering has been so rapid as to leave the lead lettering on small pedestals of marble and so no peeling has occurred. Within this study, only lettering still firmly attached to the gravestone was measured. This meant that only a certain depth of weathering could be measured before peeling occurred. If this depth was reached at different times in different environments then the age of gravestones available for measurement at the extreme end of the age range will vary between environments.

Weathering loss could vary around the lettering itself as different letters alter waterflow across the face of the gravestone. Similarly, the locations of the lettering on the gravestone could affect the weathering loss measured. A letter in the centre of the gravestone is usually part of a large section of writing which receives the runoff that has already covered and potentially reacted with a portion of the gravestone. For this study the same letters in similar locations on each gravestone were used for measurements. The letters were a ‘1′ (one), an ‘A’, an ‘E’ and an ‘O’. Two examples of each letter were measured at their top and base on each gravestone. As far as possible, four letters in the sentence giving the date of death and four letters from the name were measured. This ensured that similar locations were measured on each gravestone. From these letters an average loss for the gravestone as a whole was used to describe its weathering behaviour.

Only vertical, planar and unornamented gravestones were used in the study. Gravestone geometry and particularly ornamentation could influence the flow of water across the marble surface. Likewise, capillary rise from the ground could enhance weathering of the lower portions of the gravestone. Choosing lettering from the name and date of death usually meant that the lower portions of the gravestone were not included in the study. Gravestones with overhanging trees from which drips could affect the surface were avoided for similar reasons. Lastly, every gravestone measured had an east-facing inscription, ensuring that similar exposures were compared between environments.

SITE SELECTION

Six locations were selected for this study to permit comparison of different weathering environments (Figure 1). Clacton-on-Sea (referred to as Clacton) and Portsmouth are urban coastal sites, Oxford and Lodge Hill are inland urban sites. These urban sites could be contrasted with each other to assess whether inland and coastal urban weathering rates differed. Weathering from two urban sites, Oxford and Clacton, could also be compared to losses from rural counterparts on the coast and inland. These two urban/rural pairings of sites permitted an assessment of the impact upon weathering loss of differing pollution histories in otherwise similar weathering environments. From this design an initial assessment of the relative significance for weathering of each type of environment–coastal, inland, urban or rural–could be made.

Urban areas of a similar size were selected to try to obtain locations that would have similar urban services and functions and, by implication, similar pollution production associated with these. Selection did highlight a problem mentioned by Cooke *et al.* (1995): the variable nature of urban areas. The urban and rural sites were defined according to land-use criteria used by Warren Springs Laboratory (1972) in the establishment of their network of sulphur dioxide monitoring sites. Definition depended upon the presence or absence of certain types of land use within 400 m of the site. Land use within a 1 km radius of the graveyard had to be either continuous residential or commercial or a mixture of the two for an urban classification in this study. All the urban areas had some industrial activity within their boundaries, but it was located beyond the range

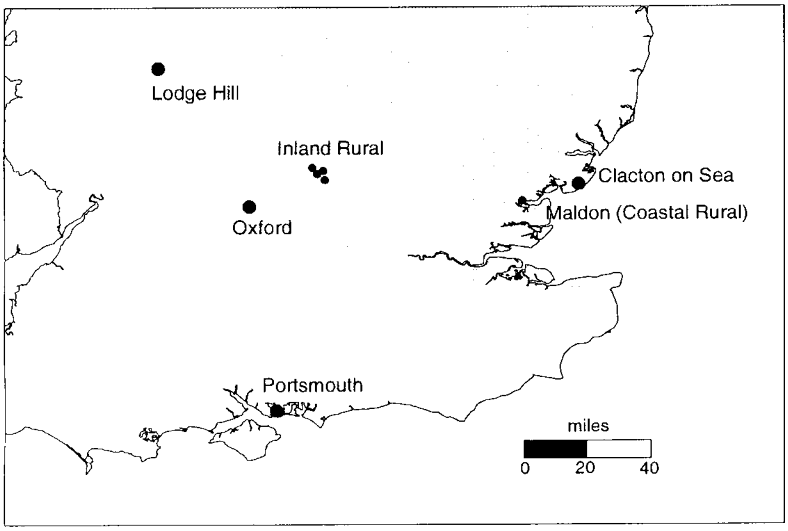

Figure 1. Location of sites

specified by the classification. Unfortunately it was not possible to assess if this had always been the case, nor if the current land use had always been present. This raises the possibility that any observed differences may result from differing rates of urban growth or differing types of former land use rather than differences between solely coastal and inland conditions. Without detailed reconstruction of the pollution history of each local area using documentary sources there is no way to be certain of the detailed history of the weathering environment.

The rural locations were selected on the basis of having none or very limited residential or commercial activity within 1 km of the graveyard, a modified criterion from the Warren Springs Laboratory classification. One problem did arise from the large number of samples collected for comparison between environments. Four separate inland graveyards – Cheddington, Ivinghoe, Mentmore and Pitstone – were needed to collect the number of samples required. Comparison of the mean weathering rates from each graveyard implied that there was no significant difference between the villages. It was assumed, therefore, that these data could be aggregated to make one sample, the inland rural sample. A small step in the data for these sites occurs between gravestones younger and older than about 70 years of age. This is not an artefact of combining datasets, it is a ‘real’ change for two of the four rural sites. The change may result from differences in the detailed weathering histories at each site or from microenvironmental differences. The latter could result from repair work or landscaping of a churchyard at the sites. The relatively small size of each rural graveyard could mean that small events such as changes in parish practices could have a dramatic impact upon care of the gravestones or their conditions of exposure and so influence weathering loss. At the coast a single graveyard of sufficient size, Maldon, was located so that only one location was required.

Analysis of rainfall data for weather stations near to each location (Meteorological Office, 1888–1964) suggested that the amount and variability of this climatic factor has been similar at each location so that this variable does not appear to be a strong candidate as an explanatory factor for any variations observed.

MEASUREMENT METHOD

Sampling began at the northernmost corner of the graveyard and continued until sufficient samples had been collected or the graveyard was exhausted of samples. The age of the gravestones sampled usually varied between 40 and 120 years. Within each graveyard, samples were collected, where possible, to cover this time span although the age distribution was not identical in each. At least 50 gravestones were measured in each weathering environment, providing a total of over 500 samples for analysis.

Table I. Mean depth of loss and weathering rates

Location	Mean depth of loss (μm)	Standard deviation	Mean weathering rate (μm a^{-1})	Standard deviation
Clacton	444	162	6·360	1·347
Portsmouth	719	140	8·172	1·274
Oxford	634	306	8·206	2·633
Lodge Hill	648	212	8·341	2·181
Coastal rural	461	171	6·042	1·217
Inland rural	251	146	3·175	1·419

Table II. Comparison of weathering rates between sites (statistically similar weathering rates noted using the Mann–Whitney U-test at $\alpha = 0{\cdot}05$)

Location	Locations with statistically similar weathering rates
Clacton	Coastal rural
Portsmouth	Oxford, Lodge Hill
Oxford	Portsmouth, Lodge Hill
Lodge Hill	Portsmouth, Oxford
Coastal Rural	Clacton
Inland Rural	None

RESULTS AND DISCUSSION

Comparison of mean weathering rates

Table I outlines the mean depth of loss and mean weathering rates for each location. The mean depth of loss is variable between locations and partly reflects the different age distributions of the gravestones measured, whilst the mean weathering rate reflects a loss per year. Statistical comparison of pairs of locations using a Mann–Whitney U-test (Table II) suggests that the coastal site of Clacton and its nearby rural counterpart have statistically similar weathering rates, but these two sites have statistically siginificantly lower weathering rates than the other urban sites in the study. All the other urban sites have statistically similar weathering rates. The inland rural site has a statistically significantly lower weathering rate than its urban counterpart of Oxford. Yearly weathering rates for all sites are, however, beyond the sensitivity of the callipers and even the significant differences between sites would take as long as 100 years to be measurable. For these reasons weathering rates will not be considered in any more detail.

Linear regression analysis

Analysis of gravestone data has usually taken the form of simple linear regression (e.g. Dragovich, 1986; Kupper, 1975). This form of analysis has assumed that weathering of marble will be relatively constant over time and vary directly with the length of exposure of the gravestone. Colman (1983) suggested that such a relationship might be expected as marble would be dissolved by acidic rainfall which would remove material in a regular manner and not vary in its intensity of operation over time. Colman described such a time-independent weathering agent as congruent. A simple linear regression analysis would indicate if the weathering loss over time followed a generally linear trend and so the presence of a congruent set of weathering processes.

Simple linear regression suggested that the constant and the gradient coefficient for depth of stone loss and age relationship are statistically significantly different from zero (Figure 2). At each site the intercept value does not pass through zero. A non-zero intercept for depth of stone loss has been noted by other authors (e.g. Klien, 1984; Inkpen, 1998) and could indicate a period of relatively low or high weathering loss before a linear relationship is established. With application of both a quadratic and cubic function to the data there is a slight improvement in the r^2 values for each relationship for each graveyard. The assumption that the regression line must intercept at zero is a physically valid one; at time zero, no loss will have occurred.

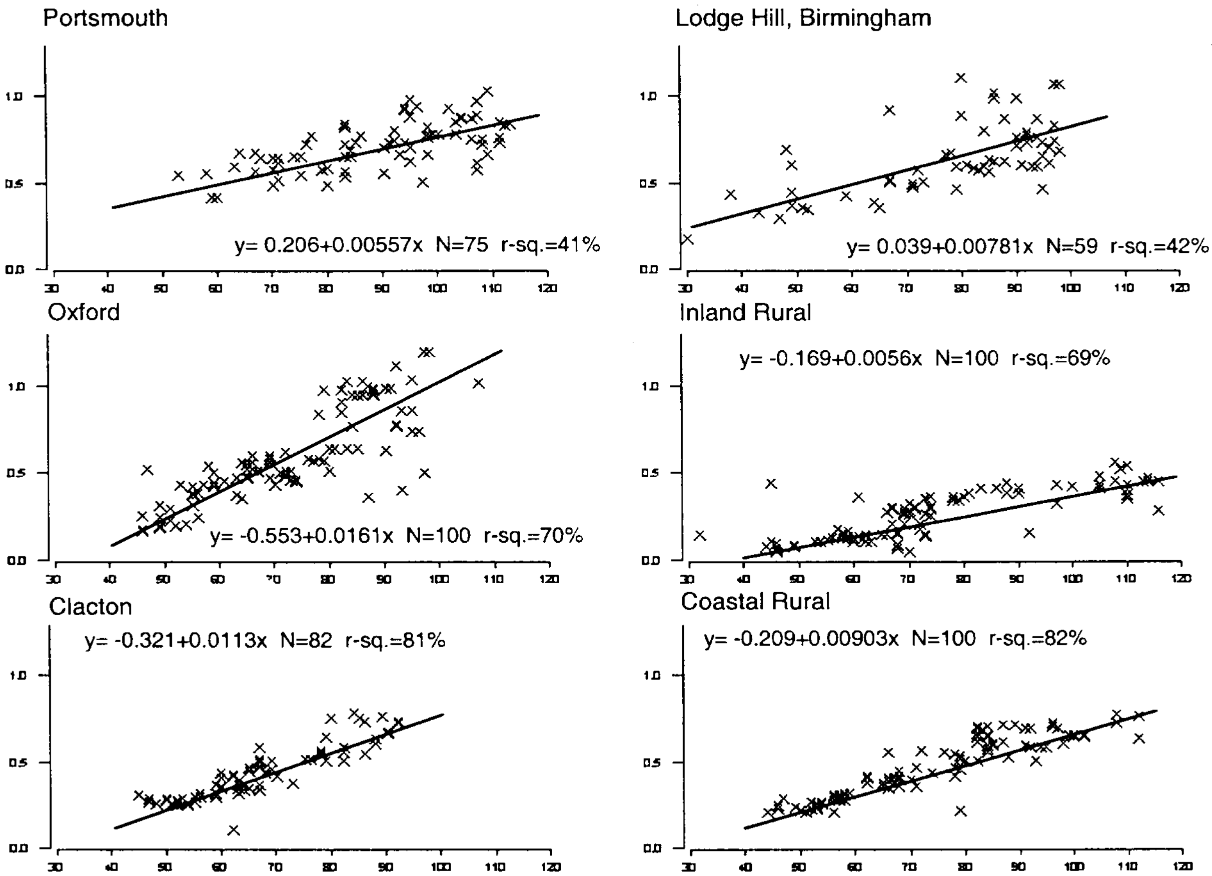

Figure 2. Regression lines and equations for all sites

Extrapolation of linear regression analysis beyond the limits of the data set is, however, difficult and liable to this type of expectation. The regression equations used only describe the relationships within the age limits of the data sets. The non-zero intercepts suggest that some other type of relationship may influence the early weathering of the gravestones. The lack of non-zero intercepts does not in itself imply that the linear regression for gravestones 40–120 years old is inappropriate.

The initial weathering of a gravestone would not usually seem to fit a curvilinear relationship consistent with later weathering behaviour. Importantly, however, the linear regression does seem to accurately describe the depth of loss/age relationship over the period of measurement. There appears to be little deviation from this relationship, suggesting a continuity of weathering loss from the past to the present. The linear relationship implies that it is difficult to maintain that weathering rates were greater in the past due to greater atmospheric pollution. This may reflect the insensitivity of measurement of loss from the surface of gravestones to changes in pollution at the same location. This would imply that differences between urban areas, such as Oxford and Lodge Hill, are the result of the operation of processes that produce a consistent rate of loss over a time scale of *c.* 100 years.

Caution should be exercised in stating that there is no increase in weathering rate over time. The measurement technique used is only sensitive to 0·01 mm; changes in weathering rate of less than this may not be measured over the time scale available and even if changes of this magnitude are present they may not greatly affect the significance of a linear regression analysis. It should be noted that the oldest gravestones measured are those with lead lettering still remaining intact. These may represent gravestones with lower weathering rates than those that have lead lettering in an unfit state for measurement. If this is the case then

the oldest gravestones sampled may be indicating an abnormally low weathering rate for a particular period of time.

Klien (1984) suggested that initially the surface polish would retard weathering loss. A smooth surface would reduce the contact time between runoff and marble and so reduce potential losses from dissolution. Changes in the properties of the stone or the intensity of episodic weathering processes over time could, however, mean that as exposure time increases, the surface area available for weathering might also increase as surface roughness increases. Additionally, the smooth surface may retard the establishment of organic growth on the gravestone surface and so reduce its potential weathering effects in the early years of exposure. Once the surface polish was removed, however, a short burst of rapid loss could be replaced by a more linear relationship.

The data suggest that within the measurement limits of this study the relationship is linear, with r^2 values of between 40 and 82 percent, implying that congruent weathering processes dominate. The relationship appears to be strongest in the urban and rural coastal graveyards in Essex. This may point to the additional influence of marine salts as the weathering agent in this particular location. Supply of this weathering agent would be relatively consistent, reducing variability that may result from the episodic spatial and temporal patterns of supply of other weathering agents.

A visual assessment of the plots of residuals against predicted y values suggested that there was no systematic variation between the two except for a slight 'fanning out' of the Oxford data at very high predicted values, although this pattern involved only seven data points and had little impact on the analysis. This suggests that although there is little heteroscedasty in the data sets, any interpretation of the Oxford data should be treated with caution.

Analysis of covariance

The relationship between age and weathering loss between locations can also be contrasted using analysis of covariance as in Cooke *et al.* (1995). In this technique, the simple bivariate regression equation used is:

$$Y_i = \alpha X_{oi} + \beta X_{1i} + \epsilon_i \tag{1}$$

where Y is the weathering loss, i each gravestone, X_1 the predictor variable, β the regression slope, the random term and α the regression intercept term. This equation has two fixed parameters, the intercept and the slope. Within each graveyard, however, there may be distinct linear relationships between age and weathering loss which a single bivariate analysis of all the data would mask. Both fixed parts of the bivariate analysis can be expanded to compare potential differences between locations by the inclusion of indicator or dummy variables where 1 indicates membership of a particular location, 0 non-membership (Silk, 1977; Jones and Bullen, 1994). The intercept part of the equation can be expanded as follows:

$$\alpha = \alpha_o X_{oi} + \alpha G_{1i} + \alpha_2 G_{2i} + \cdots + \alpha_{(\mathrm{n}-1)} G_{(\mathrm{n}-1)i} \tag{2}$$

where G is the graveyard. Each term in this equation represents the differential of each graveyard from the intercept of the base or 'anchor' graveyard. The slope part of the initial bivariate equation can be expanded as follows:

$$\beta = \beta_0 X_{1i} + \beta_1 G_{1i} + \beta_2 G_{2i} + \cdots + \beta_{(\mathrm{n}-1)} G_{(\mathrm{n}-1)i} \tag{3}$$

Each term represents the differential of the slope of the relationship in each graveyard from that of the anchor site. Combined, these two expansions give an expression for analysis of covariance:

$$Y_i = \alpha_o X_{oi} + \beta_o X_{1i} + \alpha_1 G_{1i} + \beta_1 G_{1i} X_{1i} + \alpha_2 G_{2i} +$$

$$\beta_2 G_2 X_{1i} + \cdots + \alpha_{(\mathrm{n}-1)} G_{(\mathrm{n}-1)i} + \beta_{(\mathrm{n}-1)} G_{(\mathrm{n}-1)} X_{1i} + \epsilon X_{oi} \tag{4}$$

where the first two terms represent the intercept and slope values for the anchor graveyard against which the other terms are contrasted. Additionally, the mean age of the gravestones as a whole dataset can be subtracted from the age of each gravestone. This means that the y-axis now represents the mean age of gravestones in the dataset. Intercepts for each graveyard can now be thought of as representing the amount of loss expected for a gravestone of overall mean age within each graveyard. This also helps in ensuring that intercepts are not compared by extrapolation beyond the dataset limit to some hypothetical y-axis where gravestone age is zero.

Comparing the intercept values, three of the urban sites have statistically similar values: Portsmouth, Oxford and Lodge Hill. This would imply that for an average-aged gravestone in this dataset within these urban sites there is a similar weathering loss. The other urban site, Clacton, has a significantly lower intercept value, but one that is still statistically significantly higher than both the coastal and inland rural sites. Likewise, the rural sites have intercept values significantly different from each other, with the coastal site having a higher intercept value. This would suggest a distinct weathering loss for an average-aged gravestone between the coastal urban/rural pair as well as between the inland urban/rural pairing. The lack of similarity between rural sites suggests that there may be a distinct coastal effect on weathering even without the influence of urban environments.

Comparison of the gradient coefficients, i.e. the rate of loss or weathering, suggests a more complicated picture. The coastal urban/rural pairing has statistically similar rates of weathering over the measurement period. This suggests that processes causing weathering are operating at similar rates in both environments. The amount of weathering is different as the significantly higher intercept value for the coastal urban sites implies. The weathering rate at Clacton, however, is significantly higher than the weathering rate at the other urban locations, except Oxford. Any suggestion that this may represent a coastal influence on weathering, however, is at odds with the relatively low gradient coefficient for the other coastal site at Portsmouth.

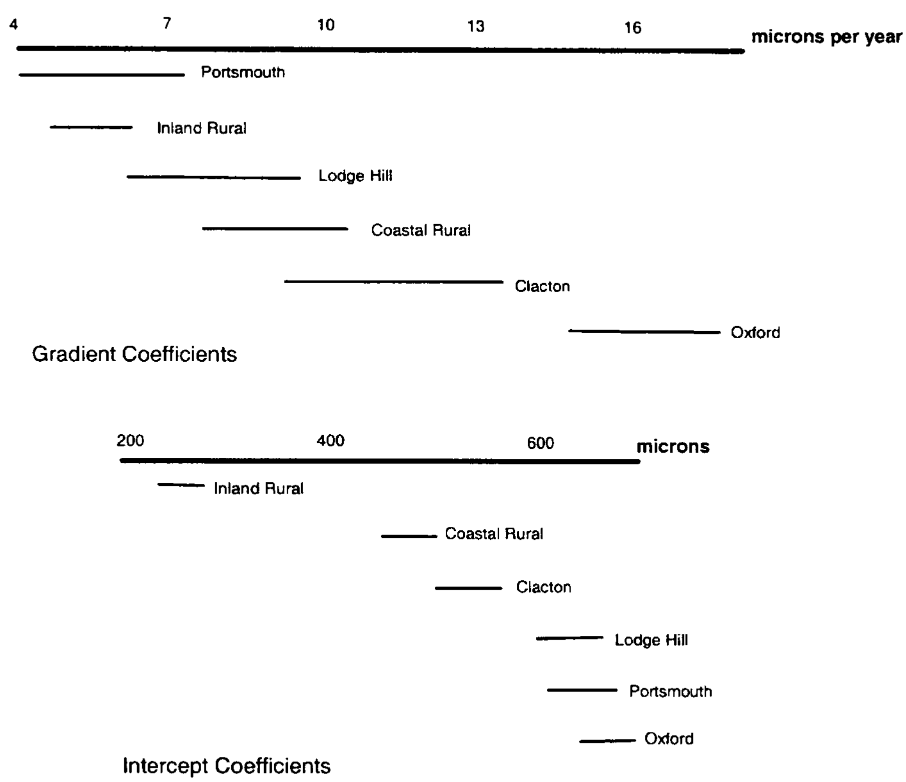

Figure 3. Comparison of 95 percent confidence interval values for gradient and intercept coefficients for each anchor site from analysis of covariance

Table III. Analysis of covariance: depth of loss against age

Anchor site	Contrast sites: Clacton	Portsmouth	Oxford	Lodge Hill	Coastal rural	Inland rural
Clacton		**−4·19**	**3·92**	**−2·64**	−1·85	**−5·03**
Portsmouth	**−4·92**		**9·2**	1·69	**2·99**	−0·17
Oxford	**−7·02**	−0·97		−7·41	**−7·11**	**−11·66**
Lodge Hill	**−4·69**	0·56	1·73		1·13	*−2·21*
Coastal rural	**−2·98**	**8·1**	**11·52**	**8·19**		**−3·99**
Inland rural	**14·67**	**18·7**	**25·01**	**19·79**	**13·48**	

Entries in italic are significant at $\alpha = 0{\cdot}05$
Entries in bold are significant at $\alpha = 0{\cdot}01$
Bottom left of the table are *t* values for the intercept coefficient, top right are *t* values for the gradient coefficient

Oxford has a significantly higher rate of weathering than all the urban sites, whilst Portsmouth and Lodge Hill have similar rates of loss. These latter two urban sites, however, also have similar weathering rates to the inland rural and coastal rural sites repsectively. The relatively low r^2 values for Portsmouth and Lodge Hill imply a wider spread of values than for the other sites in the study and could partly explain the similarity between their weathering rate and that of the two rural sites.

Interpretation of the analysis of covariance needs to be made with caution. When using analysis of covariance, although the magnitude of contrasts between sites may not alter, their significance can depending on the dataset size and the variability of data from each graveyard. Changing the number of sites and the variance of the residuals influences the standard error which in turn alters the standard deviations for each location. Using a significance level is, therefore, problematic if the contrast between some sites is close to the conventional $\alpha = 0{\cdot}05$ or $\alpha = 0{\cdot}01$ significance levels. This also suggests that, in some cases, the significance of a contrast may alter as sites are added or subtracted from the dataset.

To aid interpretation, as well as significance levels, it is probably useful to express relationships derived from analysis of covariance in terms of confidence intervals, as noted in the epidemiological literature (e.g. Unwin *et al.* 1997). Figure 3 shows the lower and upper values for the 95 per cent confidence levels for both the intercept and gradient values derived from analysis of covariance. Figure 3 confirms the patterns identified in Table III, but provides an immediate visual impression of the magnitude of the differences between each site and the degree of overlap between the sites with statistically similar gradient and intercept coefficients. The figure illustrates the slight overlaps between the gradient coefficients (0·3 and 0·5μm per year respectively) for Clacton and Lodge Hill, and Lodge Hill and the inland rural sites. Slight differences in the calculation of the standard errors and variances can produce such slight overlaps despite implying significant differences between datasets (Goldstein and Healey, 1995).

Figure 3 also emphasizes the variability between supposedly similar urban sites. This suggests that great caution is required in using current impressions or classifications of a site for historic analysis. Even broad classes such as 'urban' and 'rural' seem to hide a wealth of significant factors that can influence weathering at sites of the same class. Detailed reconstruction of past weathering environments, of which pollution is only a part, would help to identify key events or factors that influence the weathering of gravestones at each site. This may mean, however, that the simple categorization of sites is no longer possible. The uniqueness of the history of each site may, in some cases, be more significant than the assumed similarity of urban sites in determining weathering losses.

CONCLUSION

Analysis of historic weathering losses from six graveyards covering the categories urban coastal, urban inland and their rural counterparts, suggests that there are distinctive differences between each location in the strength of the relationship between age and weathering loss. Despite this, there are patterns of similarities in the weathering rates and relationships between graveyards. Differences between coastal and inland urban

sites and the coastal rural site may result from the classification being an inadequate representation of the historical activities and environments of the locations.

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